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The Marine Laboratory
Institute Of Marine Science
UNIVERSITY OF MIAMI

MESOSCALE STUDIES OF INSTABILITY PATTERNS AND WINDS IN THE TROPICS

Third Interim Technical Report
1 January 1963 - 30 April 1963

to

U. S. Army Electronics Research and Development Laboratory
Contract No. DA-36-039 SC-89111

July 1963

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To extend knowledge of tropical mesometeorology for non-hurricane disturbances; to investigate the utilization of weather radar for filling tropical data voids; to develop short-range forecasting techniques for mesoscale systems in the tropics.

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PURPOSE

This research is directed toward mesoscale studies of instability patterns and winds in the tropics. Of primary concern are waves in the easterlies which affect Southern Florida and adjacent waters.

The purpose of this research is:

1. to advance knowledge of tropical mesometeorology, particularly with respect to waves in the easterlies.
2. to investigate the utilization of weather radar for filling data voids in the tropics.
3. to develop short-range forecasting techniques for mesoscale systems in the tropics.

The research was initially divided into tasks as listed in the First Interim Technical Report [1]. Work is planned around these tasks for several case studies. Criteria for case selection were described in the above report.

ABSTRACT

Comparison of echo motions with winds aloft for a case study of 1800Z, 25 August 1961 is presented. Particular reference is made to the translational motion of precipitation echoes in the tropics, as determined by tracking selected small echoes and cells. These echo motions agree best with the 3-23,000-ft mean-layer wind, with both the 3-10,000-ft mean-layer wind and the 10,000-ft wind as next best.

Preliminary results of an echo-height study of certain mesoscale waves in the easterlies are also included. These results essentially suggest that a well known classical cloud pattern for synoptic-scale waves in the easterlies is valid on the mesoscale as well.

PUBLICATIONS, LECTURES, REPORTS AND CONFERENCES

Publications, lectures and reports

Draft copies of a paper by Harold P. Gerrish to be presented at the Third Technical Conference on Hurricanes and Tropical Meteorology in Mexico City, Mexico, 6-12 June 1963, were submitted to the U. S. Army Electronics Research and Development Laboratory for approval. This paper, entitled "An Echo-Height Study of Certain Mesoscale Waves in the Easterlies", was also given at the April meeting of the Miami Meteorological Society.

Conferences

There were no conferences with regard to this research during the period 1 January - 30 April 1963.

LIST OF DEFINITIONS APPLICABLE TO THIS REPORT

MESOMETEOROLOGY	- Mesometeorology is the study of meteorological systems which range in size from 2 to 500 miles, as suggested by Fujita [2].
MESOSCALE	- Mesoscale refers to the horizontal scale of mesometeorological systems.
INSTABILITY PATTERNS	- The rather broad array of convective patterns are called "instability patterns". In the tropics this refers to phenomena which includes waves in the easterlies, sea-breeze fronts, some hurricane spiral bands (excluded from this research), etc.
WAVES IN THE EASTERLIES	- Fairly sinusoidal oscillations in the low-level tropical easterly current are referred to as "waves in the easterlies". According to Riehl [3] they are accompanied by pressure waves, and the troughs and ridges in the pressure field correspond to the troughs and ridges in the wind field. It is assumed that this correspondence is true for all scales of "waves in the easterlies".
EASTERLY WAVE	- The expression "easterly wave" is reserved for rather intense waves in the easterlies with extensive accompanying weather. Relatively large regions experience prolonged cloudiness with many areas receiving moderate to large amounts of rainfall. Tropical cyclones or hurricanes may spawn from these waves. Very few "waves in the easterlies" qualify as "easterly waves".
SCOPE OF STUDY	- The scope of this research is confined in general to the lower and middle portions of the tropical troposphere.
GEOGRAPHICAL AREA OF STUDY	- The primary area of study centers around Southern Florida and adjacent waters. Analysis of the area between 15°N-31 1/2°N latitude and 68°W-91°W longitude was considered as the minimum required for proper description of synoptic-scale systems in the primary area.
TYPE OF ECHO UNDER STUDY	- Only precipitation echoes are studied in this research. If the work "echo" appears in the report without a modifier, "precipitation echo" is assumed.

1.0 INTRODUCTION

One of the underlying themes of our over-all research is to become familiar with slow-moving tropical precipitation echoes, their appearances, their motions, their evolution, etc. Growth, decay and other propagative processes are inherent in all of these to some degree. While very little is known about these processes and their effects on echo motion, possibly some insight into the pure motion of echoes can be achieved by designing studies to reduce these effects. Relatively pure motions are also somewhat easier to interpret physically than those complicated by propagative processes. Thus, our recent studies have been oriented in this direction. Concurrently, other investigations are being made of waves in the easterlies, in particular on the mesoscale. It is planned that models will eventually evolve from these investigations.

2.0 ECHO-MOTION STUDY OF 1800Z, 25 AUGUST 1961

The situation of 25 August 1961 involved interesting weather patterns with small relatively isolated precipitation echoes appearing on radar near 1800Z. Before discussing the motion of the echoes, it will be helpful to have the synoptic situation in mind.

2.1 Synoptic Situation

2.11 Surface Situation - Figure 1 presents the surface map analyzed using 1-mb isobars for the time of interest. This type of analysis was described briefly by Gerrish and Hiser [1]. The only aspect which was essentially different from routine analysis was that as much data as possible were included in the analysis. Reports were not necessarily rejected because of diurnal effects, sea-breeze effects, etc. Proper interpretation was made

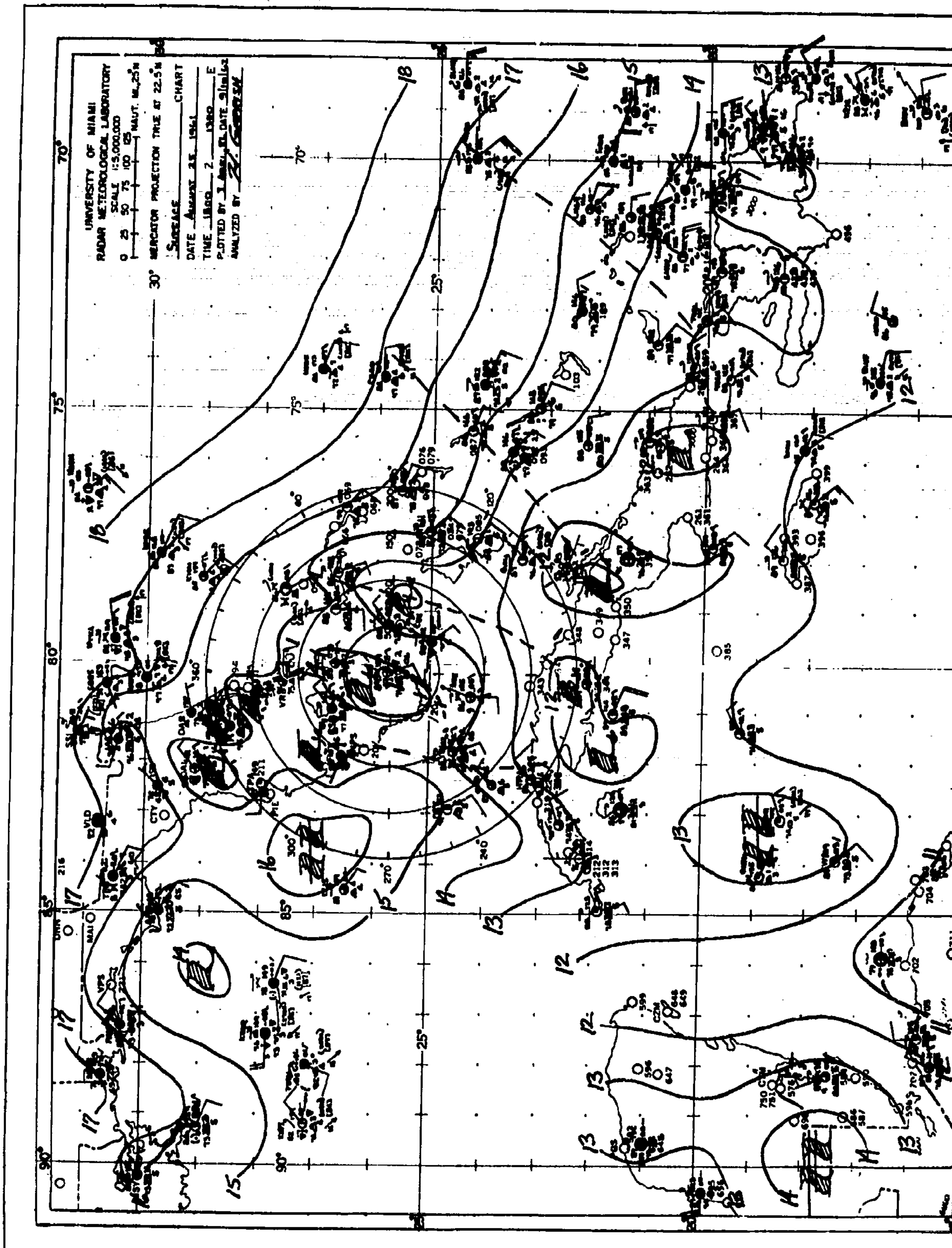


FIG.1 - SURFACE WEATHER CHART, 1800 Z, 25 AUG. 1961

later based on continuity, time sections, etc. This procedure was initially designed for test purposes and thus far has not caused major problems. The usual problems of data of questionable accuracy and large semi-diurnal pressure effects made the entire analysis extremely difficult.

Several troughs or waves with varying wavelengths can be seen in Figure 1. The three in the Southern Florida area were of particular interest. The trough which extended from Grand Bahama Island southward to Cuba moved westward at a speed of about 3 knots during the period 12 hrs before and 6 hrs after this map time. The wave near Fort Myers moved westward at nearly 8 knots during the same period. The trough immediately west of Miami possibly was associated, at least in part, with the sea-breeze regime since it could not be located on the earlier or later 6-hourly synoptic maps, on any upper-wind map, or on time sections.

2.12 Situation Aloft - Figure 2 presents the 5000-ft chart showing southerly flow in Southern Florida with a trough near Fort Myers and one over the Gulf of Mexico. The latter was associated with a surface trough in the same general area. Note that the Fort Myers wave was the only one of the three in the Southern Florida area which extended from the surface to 5000 ft. At 10,000 ft (Figure 3) the flow turned to more southeasterly in Southern Florida. Suggestion of weak troughing was indicated over the Bahamas. The troughs which were located at the lower level can be found at this level also. In addition, time sections indicated a very weak trough between Grand Bahama and Miami. This trough was forced into the analysis in Figure 3. A rather drastic change in flow pattern occurred at the 15,000-ft level (see Figure 4). The flow at this level over Southern Florida was more from the east. The Fort Myers wave had disappeared and complex troughing of

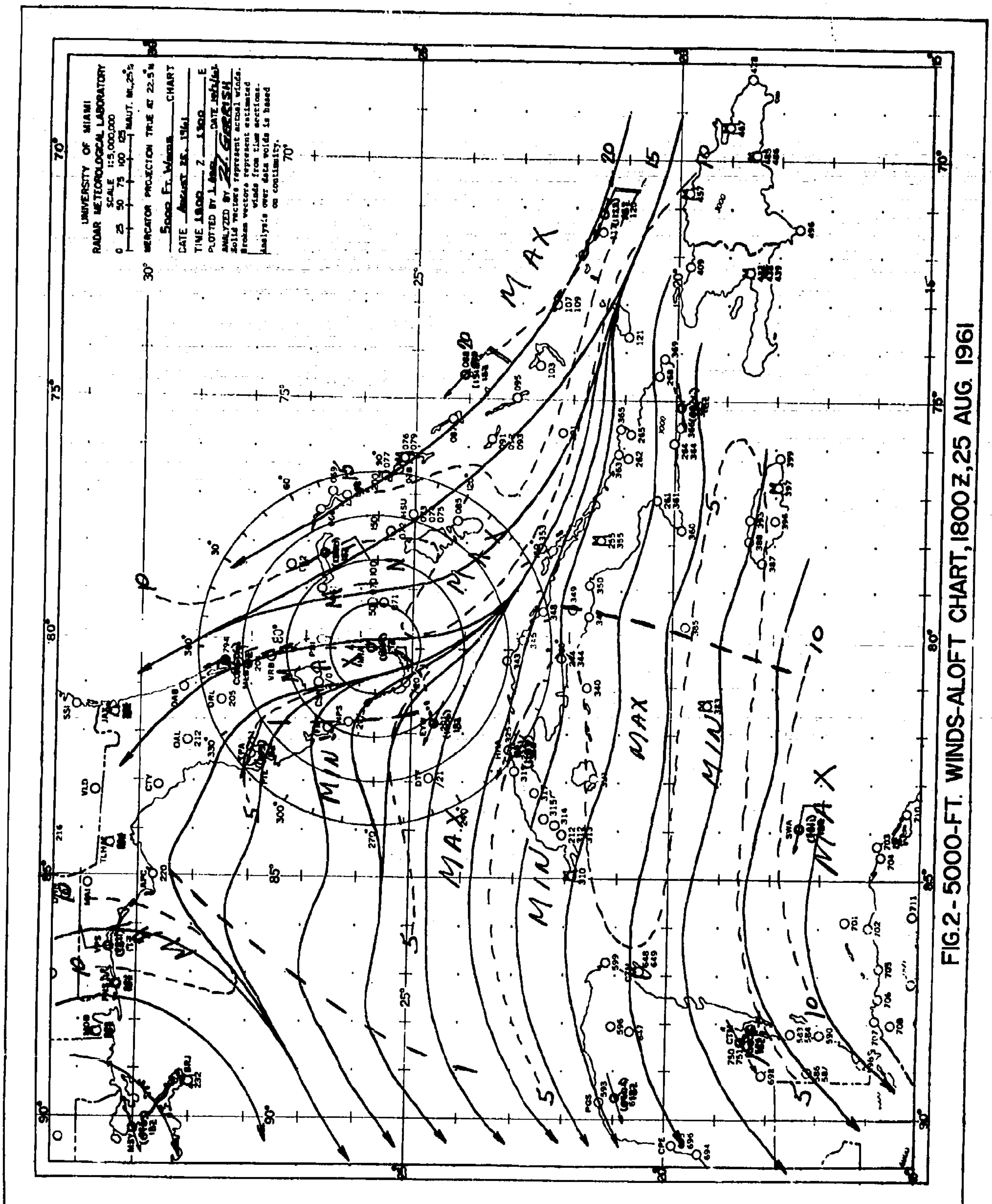


FIG.2- 5000-FT. WINDS-ALOFT CHART, 1800Z, 25 AUG. 1961

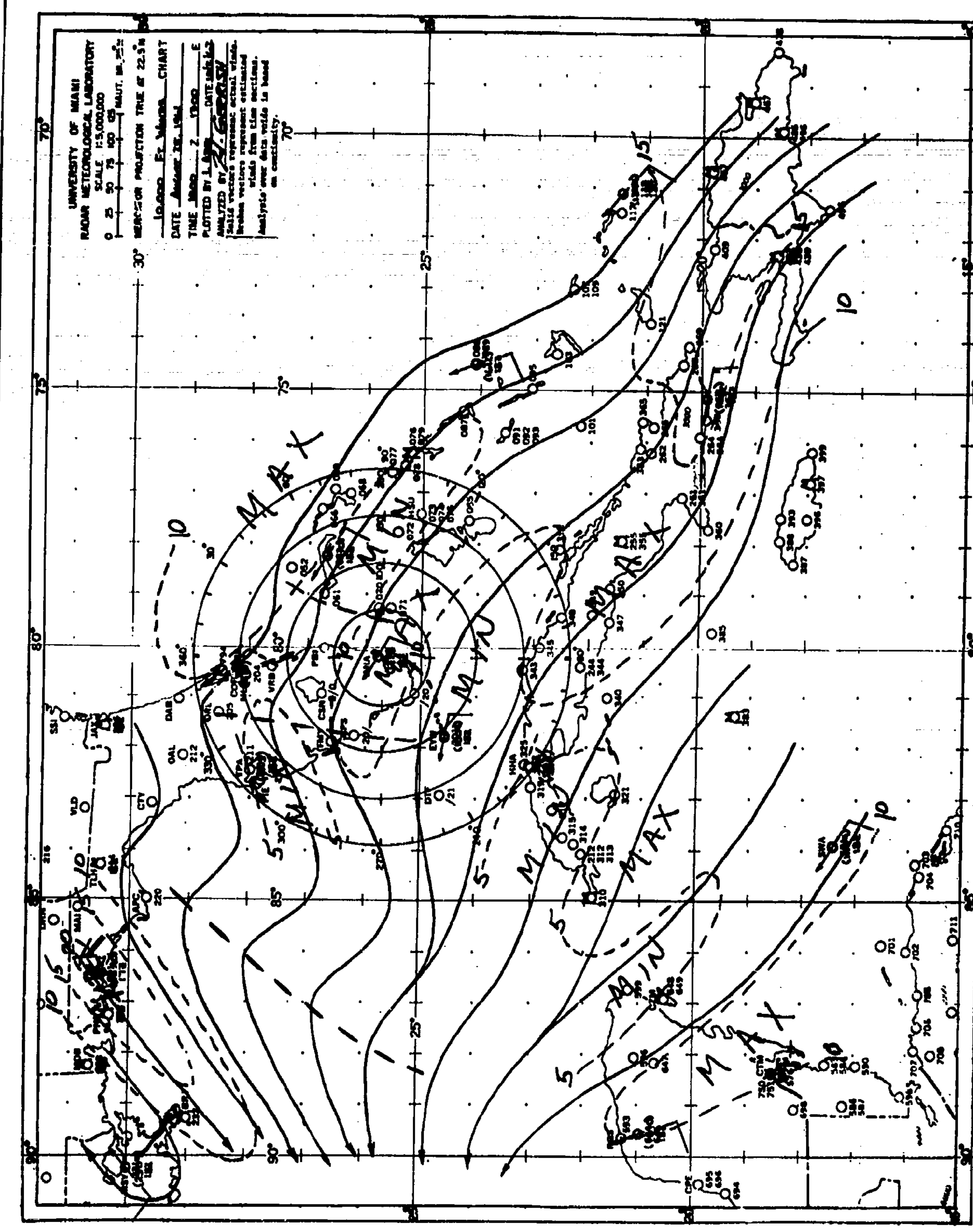


FIG. 3-10,000-FT. WINDS-ALOFT CHART, 1800Z, 25 AUG. 1961

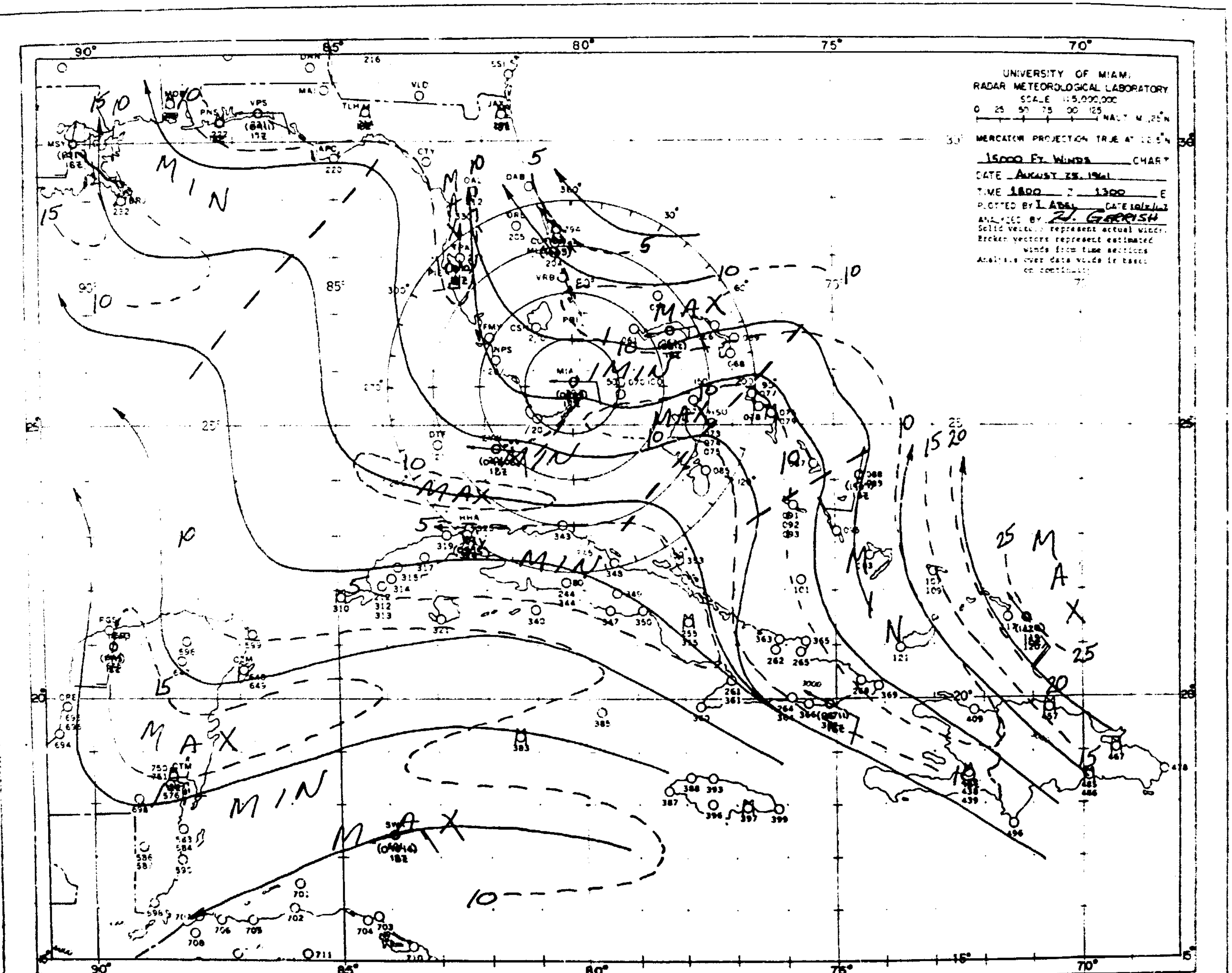


FIG.4-15,000-FT. WINDS-ALOFT CHART, 1800Z, 25 AUG. 1961

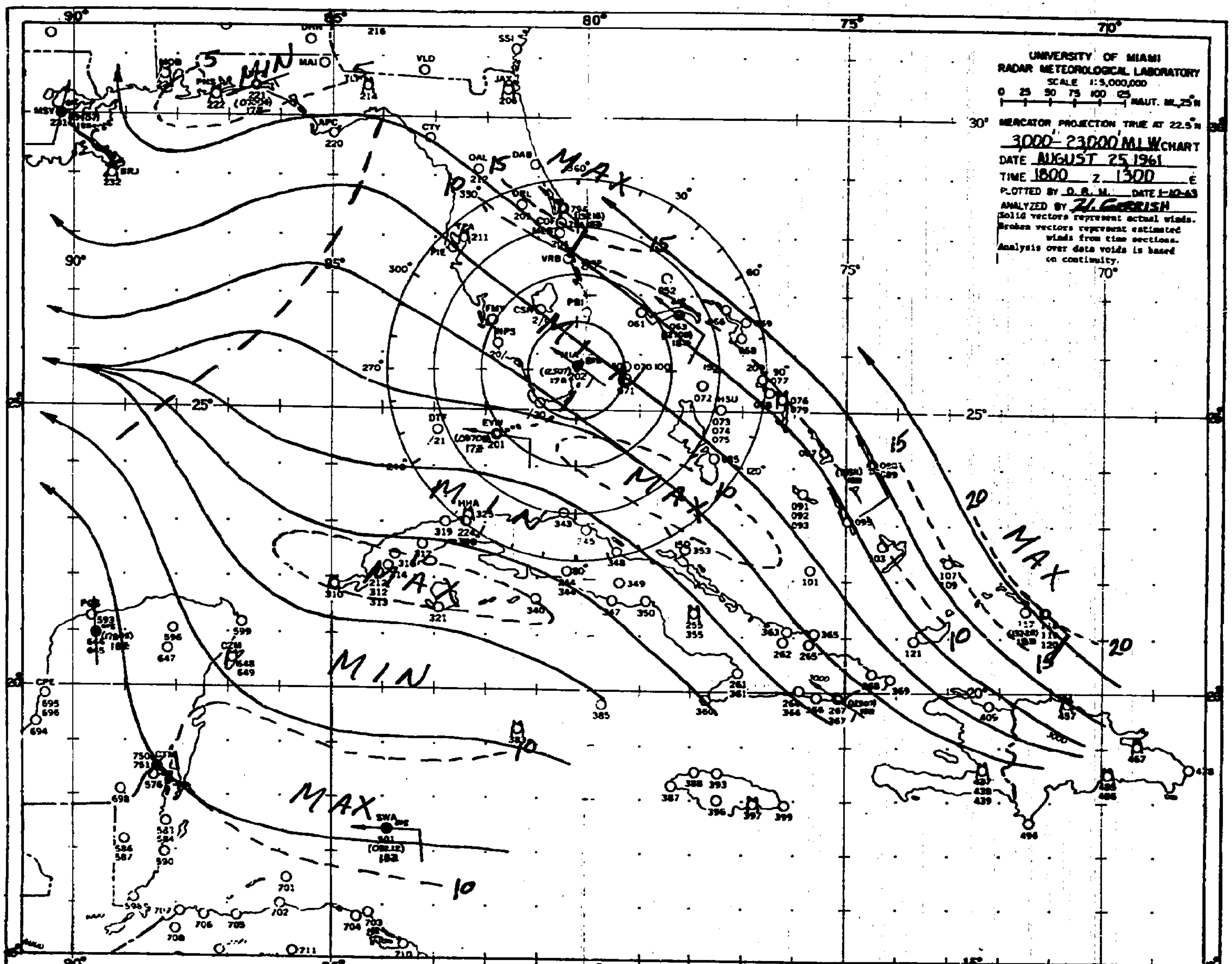


FIG.5-3000-23,000-FT. MEAN-LAYER WIND CHART, 1800Z, 25 AUG. 1961

moderate amplitude had now begun over the Bahamas. Troughing over the Gulf still persisted. The 3000-23,000-ft mean-layer wind chart is presented as Figure 5. Such a layer represents the average layer in which most precipitation echoes in Southern Florida are embedded [6]. In this particular situation quite different wind regimes were used to compute data for the chart.

Although isotachs are on the wind maps, a subjective discussion of vorticity patterns will not be made at this time.

2.2 Winds Aloft and Echo Motions

A thorough discussion of the procedure used for comparing winds aloft and echo motions and the reasoning behind it was presented in our previous report [5], and therefore will not be repeated here. It will suffice to state that these comparisons were made at grid points after space smoothing the data. The input data were based on streamline and isotach analyses.

2.21 Winds-Aloft Charts - Winds-aloft charts at 1200Z and 1800Z, 25 August 1961, and 0000Z, 26 August 1961, for the following levels and layers were plotted, and analyzed using the principles of streamline and isotach analysis:

Levels	Layers
3000 ft	3000-10,000 ft
5000 ft	10,000-16,000 ft
10,000 ft	16,000-23,000 ft
15,000 ft	3000-23,000 ft
20,000 ft	

Again higher levels and layers were not analyzed primarily because of lack of data at 1800Z. However, previous very rough analysis at higher levels [1], suggested that correlations of echo motions with flow at such

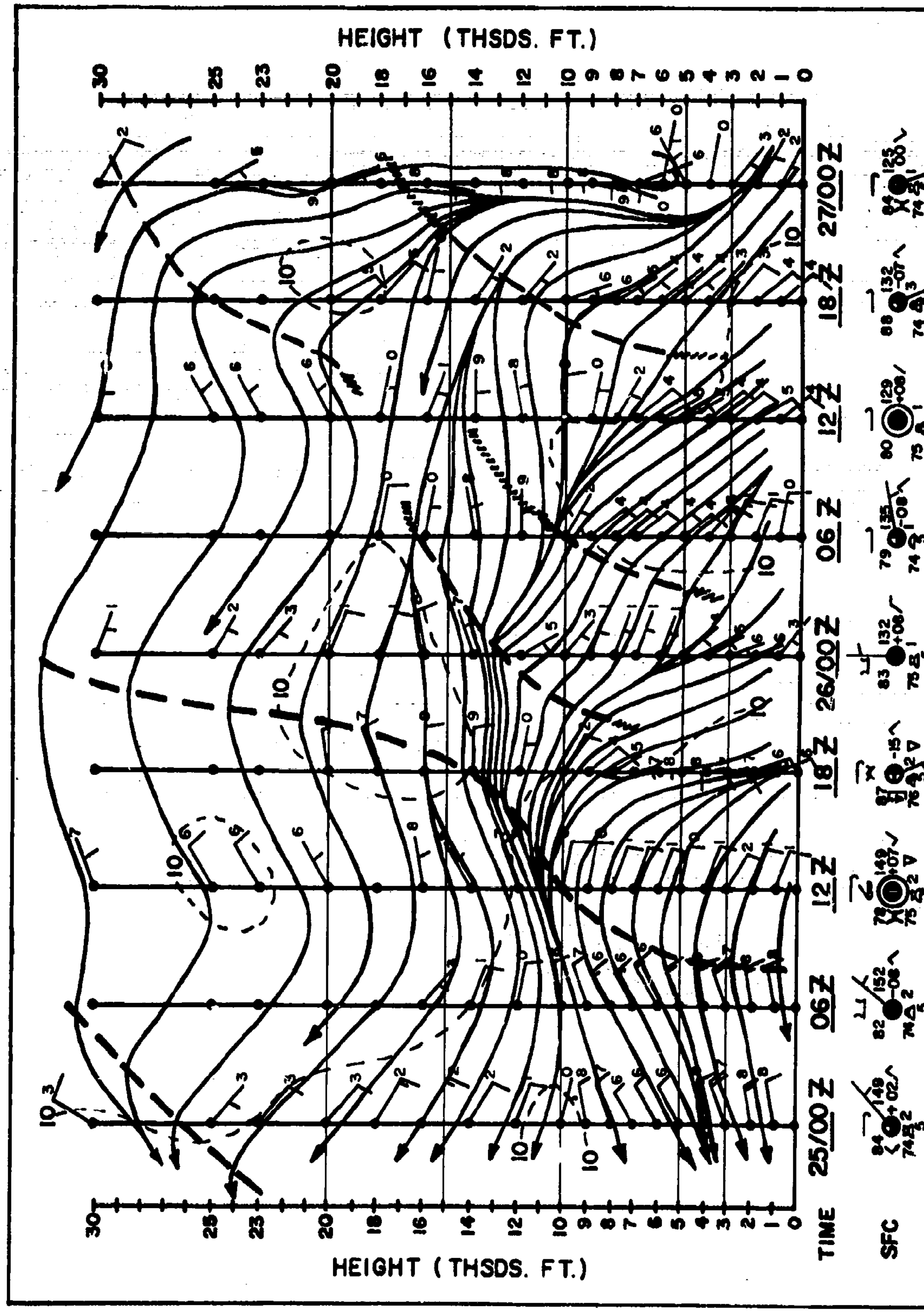


FIG.6- TIME SECTION FOR MIAMI, FLA.
0000 Z, 25-27 AUGUST 1961

levels would not be good.

As in our earlier studies, continuity was stressed in the analysis and time sections were consulted frequently. Time sections were plotted for Key West, Tampa, Cape Canaveral, Miami, Grand Bahama, San Salvador, Turks Island, and Havana. Figure 6 shows the time section for Miami. Note that lines resembling streamlines were drawn on the time section to assist with the location of mesoscale waves aloft. These lines should not be confused with streamlines of conventional analysis. They, nevertheless, proved to be quite useful for interpretation and handy to work with. In some instances, missing data were interpolated from such lines.

2.22 Echo Tracking - Procedure used for tracking echoes was also discussed at length in [5]. Since it is the translational motion of echoes that is of primary concern, propagative effects must be removed. One cannot say with confidence to what extent these effects were removed by the design of the procedure because so little is known about them. We are of the belief that, by choosing small nearly circular and relatively isolated echoes in general less than 5 n. mi in diameter, these effects are greatly reduced. In some instances relatively small duo-celled echoes were selected for tracking if each cell had the same motion and if their centroids were at least 5 n. mi apart. This prevented certain areas of the echo maps from being data voids and yet was in agreement with reducing propagative effects. Throughout the entire tracking procedure, frame-by-frame continuity for each echo was important (at 40-sec intervals in most cases) and one had to double check RHI data or other means to make sure that ships plying the waters to the east of our radar were not being tracked.

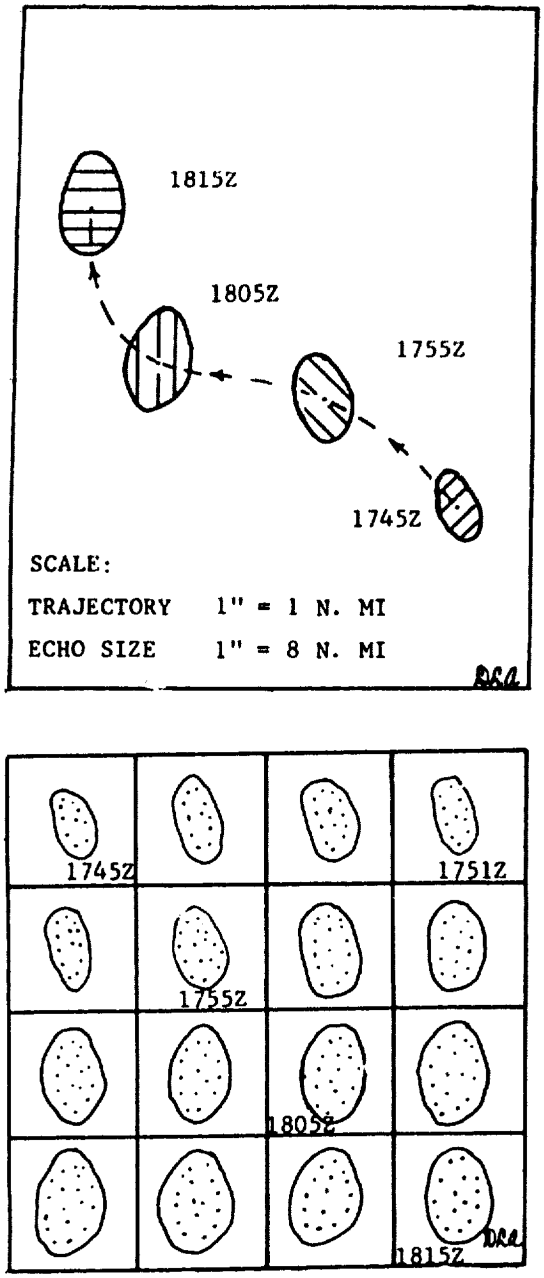


FIGURE 7 TRAJECTORY AND SHAPE HISTORY FOR ECHO 74°/35 N. MI FROM UNIV. OF MIAMI DURING THE PERIOD 1745-1815Z, 25 AUG. 1961.

Upper - Trajectory at 10-min intervals

Lower - Shape history at 2-min intervals
Scale 1" = 8 n. mi

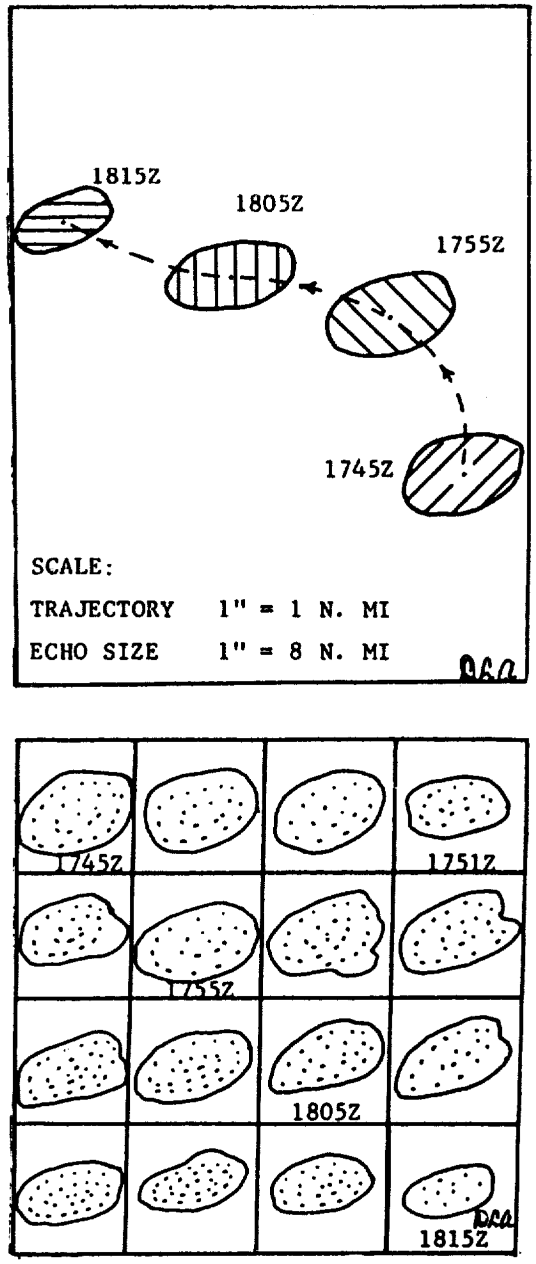


FIGURE 8 TRAJECTORY AND SHAPE HISTORY FOR ECHO 342°/56 N. MI FROM UNIV. OF MIAMI DURING THE PERIOD 1745-1815Z, 25 AUG. 1961.

Upper - Trajectory at 10-min intervals

Lower - Shape history at 2-min intervals
Scale 1" = 8 n. mi

Echoes tagged as suitable for this particular study were investigated further under an image magnification of about 64 times the 35-mm film size. (Time-lapse 35-mm film from our radar film library was used in the study). Among other reasons, this was done to better determine and measure small displacements. Shapes of the echoes were recorded during the tracking period. Echo trajectories were plotted for certain echoes at 10-min intervals, since 5-min intervals were found to be impractical [5]. Shape histories and trajectories for 2 echoes are presented in Figures 7 and 8. These particular echoes could be tracked as long as 30 min. During the period there were some minor changes in shape which did not affect identification. Major shape changes often disqualified echoes because of cell identification difficulties. Both trajectories show that these echoes apparently did not move in straight lines but rather appeared to follow some sort of oscillatory path as if affected by waves moving through the area. If these oscillations are real, high speed waves moving through the lower tropical troposphere are indicated. There still is considerable question as to whether they are real or not, because of working with extremely small echo displacements of the order of 1 mi in 10 min. Although strict procedure designed to minimize inherent errors in equipment was followed, an error of the order of one mile or slightly less seems highly probable. This will be tested for 15-min intervals and for longer periods, proper echoes permitting. Meanwhile, 10-min echo trajectories will be discontinued because of the uncertainties.

It is becoming increasingly important that all studies dealing with meteorological echoes be made on calibrated radars. The radars at the University have been the subject of various checks in the past. These include range, azimuth, and elevation, as well as periodic power checks.

However, extensive additional calibrations are planned upon completion of the installation and modification of a CPS-6B radar this summer. This radar replaces our modified SP-1M radar.

2.23 Echo-Motion Maps - The 30-min period from 1745-1815Z, 25 August 1961, was used as the period for echo tracking in this case study. The period was broken up into 15-, and 30-min periods. Echo maps with vectors depicting nearly translational motions were plotted and then analyzed using the principles of streamline and isotach analysis.

2.24 Space Smoothing - A 50-n. mi grid was used to space smooth upper-wind and echo-motion maps. Certain points on this grid were used as an 100-n. mi grid (points 2, 9, 11, 13, and 20). The grid was labeled as follows:

	1	2	3	
4	5	6	7	8
9	10	11	12	13
14	15	16	17	18
	19	20	21	

(Vertical and horizontal distances between points were 50 n. mi)

(point 11 was Miami)

50-N. Mi Grid

The types of averages were defined in [1] and [5]. Due to lack of data at outer points, the 60-n. mi grid was not used.

2.3 Comparison of Echo-Cell Motions With Winds Aloft

Figures 9-11 present diagrams showing echo-cell motions and winds aloft at grid points resulting from various space smoothings. The following key

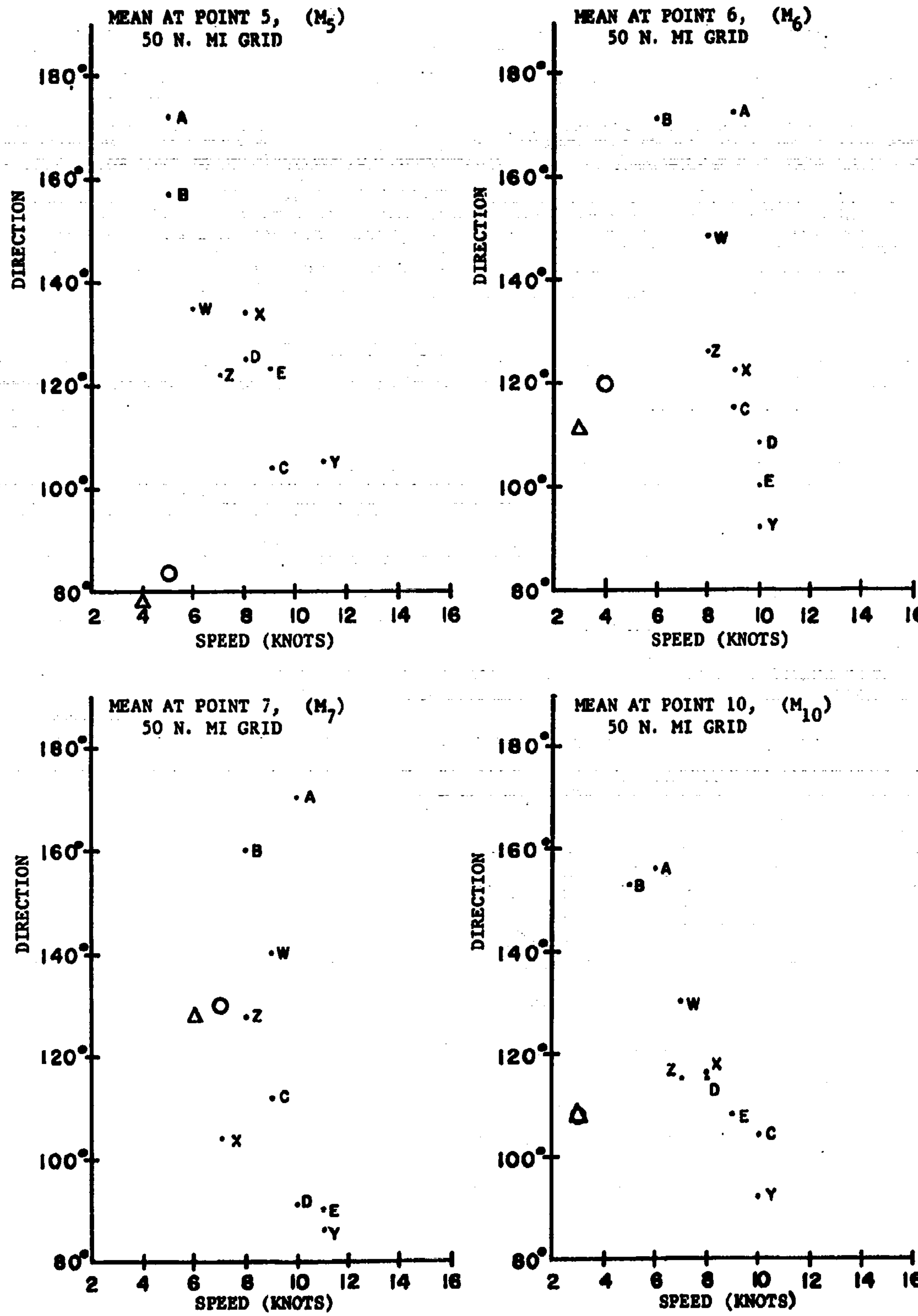


FIGURE 9 <u>Mean Echo-Cell Motions and Mean Winds Aloft at Grid Points</u>

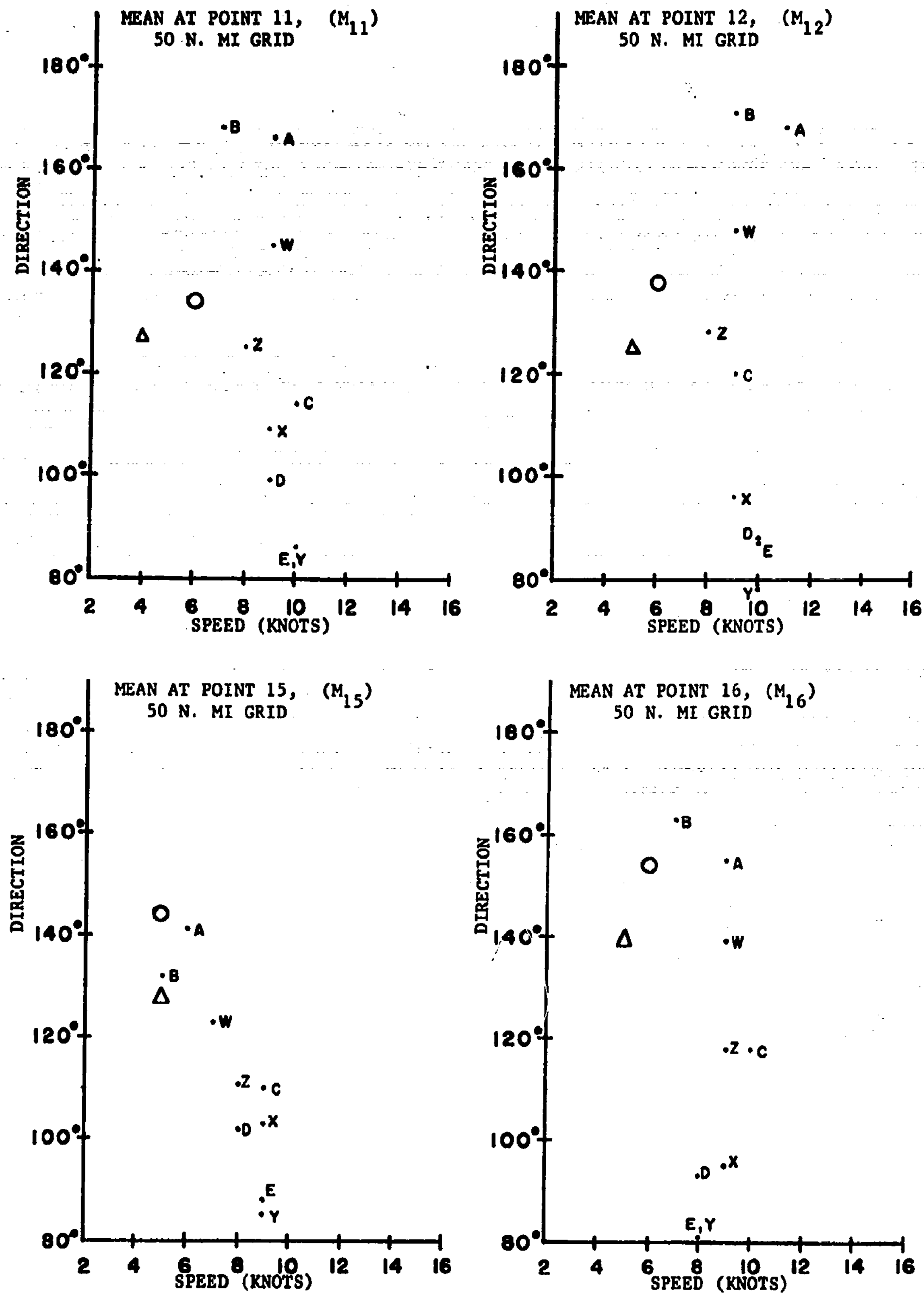


FIGURE 10 <u>Mean Echo-Cell Motions and Mean Winds Aloft at Grid Points</u>

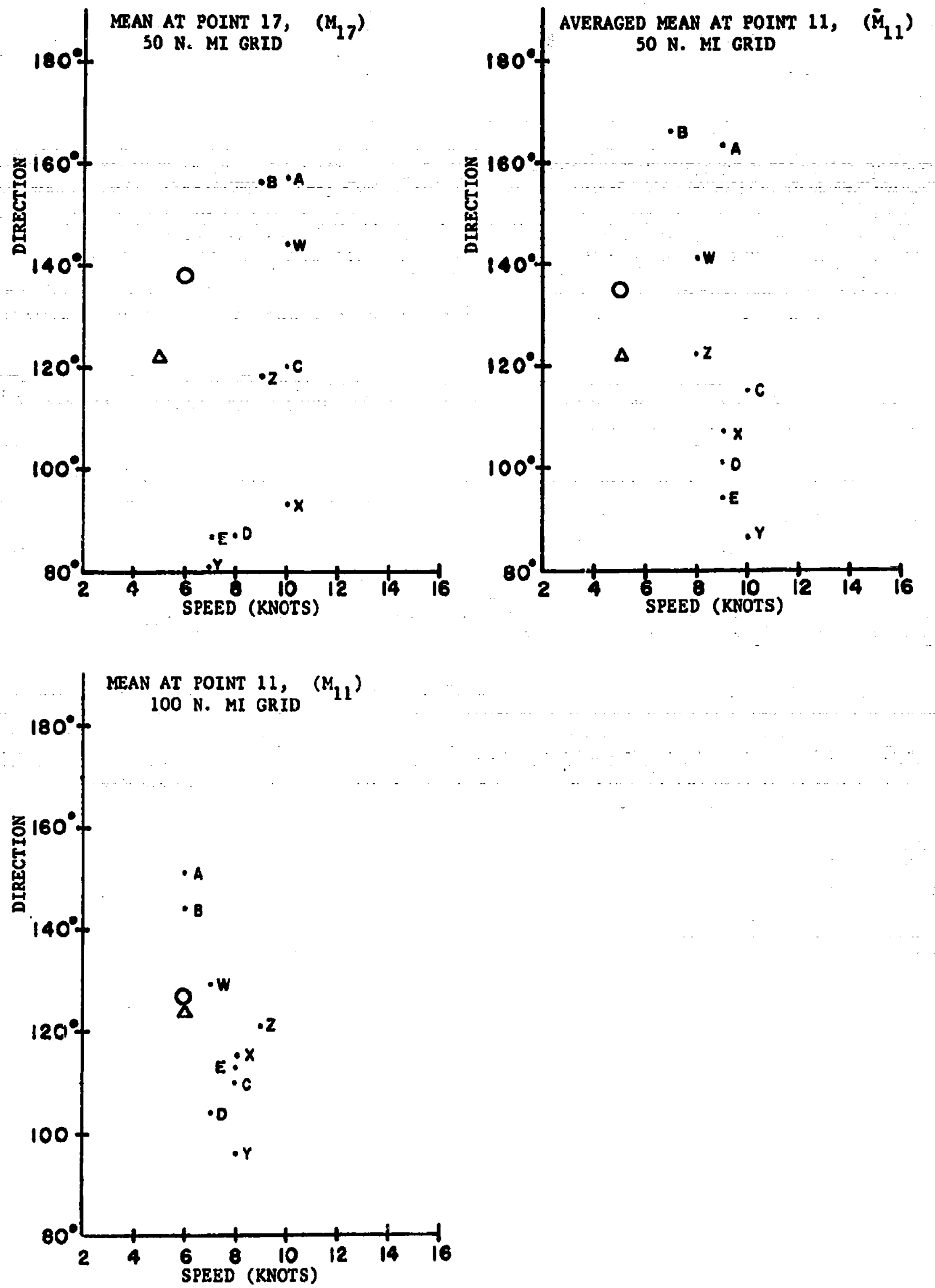


FIGURE 11 <u>Mean Echo-Cell Motions and Mean Winds Aloft at Grid Points</u>

applies to the diagrams:

KEY

Symbol	Meaning
A	mean 3000-ft wind
B	mean 5000-ft wind
C	mean 10,000-ft wind
D	mean 15,000-ft wind
E	mean 20,000-ft wind
W	mean 3000-10,000-ft mean-layer wind
X	mean 10,000-16,000-ft mean-layer wind
Y	mean 16,000-23,000-ft mean-layer wind
Z	mean 3000-23,000-ft mean layer wind
○	mean 15-min echo-cell motion
△	mean 30-min echo-cell motion

Comparisons based on Figures 9-11 appear in Table 1.

Table 1 suggests that the 3-23,000-ft MLW (mean-layer wind) verified best in this study with the 3-10,000-ft MLW and the 10,000-ft wind as next best. Although the comparisons were not as good as in [1] or [5], this was our first case studied where a mean-layer wind verified best.

2.31 Comparison of Results With Other Studies - Our earlier studies [1] and [5], indicated that the translational motion of echoes most nearly resembled the flow at 5000 and 10,000 ft, respectively, with low-level or layer winds verifying well. The current study suggests that the echo motions most nearly represent the mean flow of the 3-23,000-ft layer which is the layer in which most echoes in Southern Florida are embedded. Low levels or layers still verified reasonably well.

Considering our studies on echo motion to date, one can say that the translational motion of echoes most nearly resembles low-level flow, in

MEAN WINDS ALOFT		± 10° and ± 2 Knots 50-N. MI GRID M (9 pts)	± 10° and ± 2 Knots 50-N. MI GRID M̄ (1 pt)	± 10° and ± 2 Knots 100-N. MI GRID M (1 pt)	± 20° and ± 5 Knots 50-N. MI GRID M (9 pts)	± 20° and ± 5 Knots 50-N. MI GRID M̄ (1 pt)	± 20° and ± 5 Knots 100-N. MI GRID M (1 pt)
MEAN 3000-ft WIND	15*	1	0	0	3	0	0
	30*	0	0	0	2	0	0
MEAN 5000-ft WIND	15*	1	0	0	3	0	1
	30*	1	0	0	1	0	0
MEAN 10,000-ft WIND	15*	0	0	0	6	1	1
	30*	0	0	0	4	1	1
MEAN 15,000-ft WIND	15*	0	0	0	1	0	0
	30*	0	0	0	1	0	1
MEAN 20,000-ft WIND	15*	0	0	0	0	0	0
	30*	0	0	0	0	0	1
MEAN 3-10,000-ft MLW	15*	1	0	1	5	1	1
	30*	1	0	1	3	1	1
MEAN 10-16,000-ft MLW	15*	0	0	0	2	0	1
	30*	0	0	1	1	1	1
MEAN 16-23,000-ft MLW	15*	0	0	0	0	0	0
	30*	0	0	0	0	0	0
MEAN 3-23,000-ft MLW	15*	3	0	0	6	1	1
	30*	1	0	0	7	1	1

DEVIATIONS OF MEAN ECHO-CELL MOTIONS FROM MEAN WINDS ALOFT

15* Indicator for 15-min mean echo-cell-motion verifications
30* Indicator for 30-min mean echo-cell-motion verifications

TABLE 1 Grid Point Comparisons of Mean Echo-Cell Motions With Mean Winds Aloft. Number of instances the 15-, and 30-min mean echo-cell motions verified within the given deviation from the mean winds aloft at the grid points for which mean values (M) and averaged mean values (M̄) were determined.

particular the 5000- and 10,000-ft levels, or low-layer flow such as the 3-10,000- or 3-23,000-ft layers. Possibly a large statistical sample would narrow the selection down somewhat.

Although reasonable layers or levels verified best thus far, the vector difference between these winds and echo motions varied. In this particular study the differences was greater than in [1] or [5]. This can be due to methods used in analysis. Actually one should not expect the precipitating portion of a cloud to move exactly as a particular wind. It may not move extremely well with any wind.

2.4 Recommendations for Future Studies

Together with recommendations made earlier in the text, it would be desirable to track echoes during their entire lifetime. The average tracking time of echoes suitable for translational motion studies is desired. This may or may not be comparable to lifetime depending on shape history. This study is underway currently.

Propagative processes should be researched with particular emphasis on quantitative results. A study along such lines has been proposed.

2.5 Conclusions

1. Time sections continue to be effective aids for mesoscale-trough identification aloft.

2. Due to small echo displacements, echo trajectories based on 15-min intervals rather than 10-min interval are suggested.

3. High-speed waves probably should not be inferred from echo trajectories based on 10-min echo displacements.

4. The translational motion of precipitation echoes most nearly resembled the 3-23,000-ft mean-layer wind. The 3-10,000-ft mean-layer wind and the 10,000-ft wind verified next best.

5. The vector difference between echo motions and the wind of best verification varies considerably.

3.0 AN ECHO-HEIGHT STUDY OF CERTAIN MESOSCALE WAVES IN THE EASTERLIES

Since the paper by Harold P. Gerrish with the same title as this section [7] may not be published for several months, a large portion of it will be reproduced herein.

It should be kept in mind that the term "mesoscale waves in the easterlies" refers specifically to waves 2-500 mi in size with a basic structure similar to those as described by Riehl. Also it should be emphasized that this research represents a preliminary effort to examine the heights of convective precipitation echoes associated with certain of these waves.

3.1 Procedure

Two situations involving specific mesoscale waves in the easterlies as described above are analyzed in this paper. The procedure was to compare echo-height data in these situations with the wave positions which were previously presented in reports by Gerrish and Hiser [1] and [5]. This was done to reduce bias in the results. Several periods of growth and decay based on available RHI data were chosen as listed in Table 2.

TABLE 2 Situations and Periods Studied

Situation	Periods Studied	Comments
26 August 1961 (near 1800Z)	1737-1741Z 1741-1745Z	a) 2 mesoscale waves in the vicinity of Southern Florida, b) few PPI echoes.
8 August 1958 (near 1800Z also)	1643-1647Z 1814-1818Z 1818-1822Z	a) 2 mesoscale waves in the vicinity of Southern Florida, b) large number of PPI echoes.

A period of approximately 4 minutes was required for one horizontal revolution of the radar antenna when taking RHI time-lapse radarscope photos every 4 degrees of azimuth. Neighboring 4-minute periods were chosen since considerable growth and decay can occur in the tropics within 4-8 minutes.

3.11 <u>Analysis of Mesoscale Waves from Conventional Data</u> - Surface analysis was discussed earlier in section 2.11. Time sections were used to check for proper structure in the vertical. Figure 6 shows one such time section and additional discussion on the subject is contained in section 2.21.

3.12 <u>Echo Heights as Observed by Radar</u> - Heights of the convective precipitation echoes for each period were depicted by viewing 35-mm time-lapse RHI radarscope film taken at the University of Miami. The MPS-4 radar used to obtain this film has a vertical beam width of 0.8 of a degree and a horizontal beam width of 4 degrees. This means that the echoes were not stretched very much in the vertical although the horizontal stretching was considerable. The maximum error in height at 80 n. mi due to this half beam-width stretching is approximately 3000 ft. Range attenuation also has effects upon echo-height data; however, Hiser et al. [8] point out that these effects are nearly compensated for (with 600 ft between 40-80 n. mi) by the vertical beam-width stretching of the MPS-4 radar. Heights between 12-40 n. mi were used primarily as a guide for analysis since the top of the sweep is at varying altitudes in this range interval. The first 12 n. mi of video are usually surpressed by STC (Sensitivity Time Control) circuitry.

Because of the large horizontal beam width of the MPS-4 radar, a point target of sufficient intensity would appear on RHI frames up to 2 degrees azimuth or as much as 17,000 ft before and beyond the actual target at 80 n. mi range. Thus, some frames contained fictitious echoes as a result of effective horizontal beam-width stretching which were eliminated when describing real echo heights.

3.13 Echo-Height Maps - The procedure was to plot a map first for each period showing the bases and tops of all precipitation echoes as seen on each frame within a range of 80 n. mi regardless of beam-width stretching. There were approximately 4 degrees of azimuth between frames. Another map was then plotted for each period showing the greatest height noted for each echo. This was done on a light table by stacking the first map over the appropriate PPI display and then noting the maximum heights in conjunction with the echoes. Proper associations between RHI and PPI data were assured using this procedure. When several small echoes exhibited similar maximum tops within an area of less than roughly 15 n. mi diameter, one value was recorded for simplicity of analysis. Echo masses covering relatively large areas did present interpretation problems for the moderately intense situation of 8 August 1958. For such masses, an endeavor was made to depict the maximum height of individual convective areas within the masses. (The problem of determining the intense cores of echo masses covering sizeable areas could be resolved somewhat by: reducing receiver gain, using signal attenuators, reducing the horizontal beam width, reducing the pulse length, etc.).

Isopleths of the greatest height noted for each echo and greatest heights noted within echo masses were then drawn at 10,000-ft intervals for the various periods of the chosen situations.

3.2 Discussion of Results

Isopleths on the echo-height maps appeared to be oriented in alternating bands of maximum- and minimum-height values. For all periods analyzed, there was a tendency for the maximum-height bands to be oriented along or preferably immediately to the rear of the axes of the surface waves. This is somewhat

analogous to the classical model of clouds for synoptic-scale waves in the easterlies as described by Riehl [3].

Upper-wind charts for both situations indicate that the basic low-level current was of the order of about 10-12 knots, whereas the wave speeds as depicted from 6-hourly surface continuity were about 5 knots except for the wave just west of Miami at 1800Z, 26 August 1961, which moved closer to 10 knots. Time sections indicate that this current was rather uniform with height. One can subjectively use the theorem of conservation of potential vorticity to show that the results as indicated on the echo-height maps are generally to be expected under such conditions. Thus, the results appear to be reasonable.

Figure 12 presents the 26 August 1961 situation with the results of one period. The echo-height map suggests that for the relatively common situation containing few echoes, the correspondence between the maximum-height bands and the axes of the mesoscale waves is quite good. These bands are approximately 100 [redacted] mi apart. Wiggles and slight shifts in the bands in all situations were due to growth and decay of echoes. This, however, did not seem to effect the preference of the highest echoes to be oriented along and immediately to the rear of the wave axes. Note also that the maximum-height bands are about the same order of magnitude whether over land or water at 1737-1745Z in this situation.

It is difficult to [redacted] what effect sea-breeze fronts may have on the maximum-height band over land in Figure 12. PPI data composited from various radars in Florida suggest that portions of this band near Lake Okeechobee and just west of Miami may be affected by sea-breeze fronts (Figure 13). However, the apparent sea-breeze front along the southern coast appears to be at right

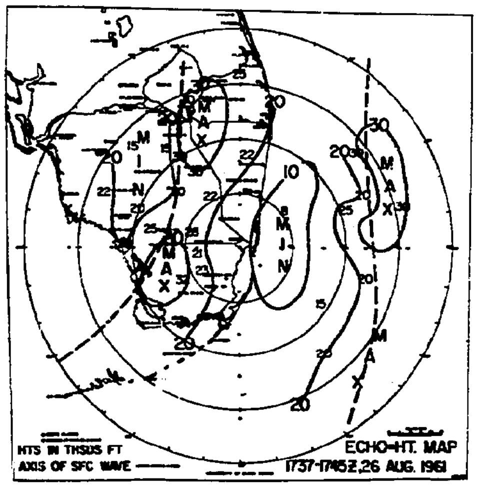
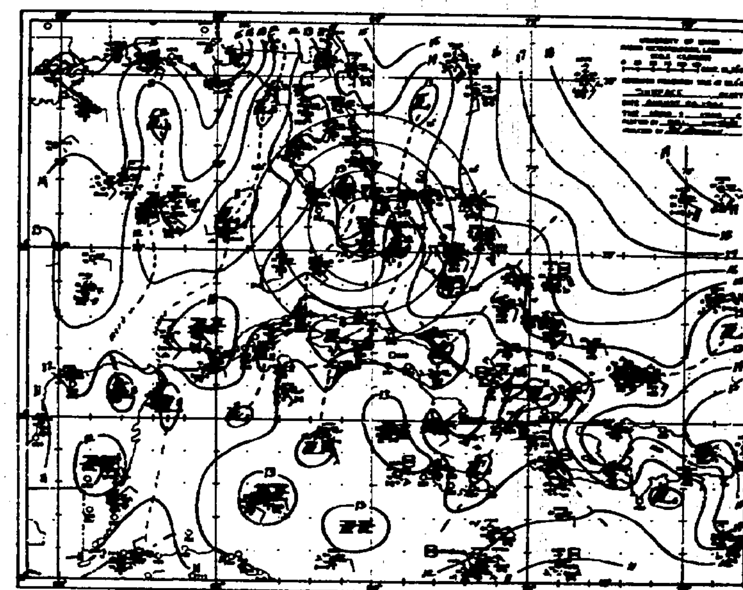


FIG. 12 — 1800Z
26 AUGUST 1961
SITUATION

Sfc. Map (Right)
Echo-Ht. Map (Left)



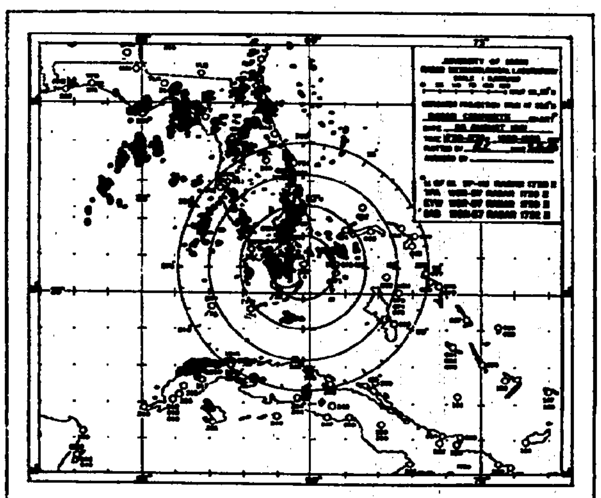
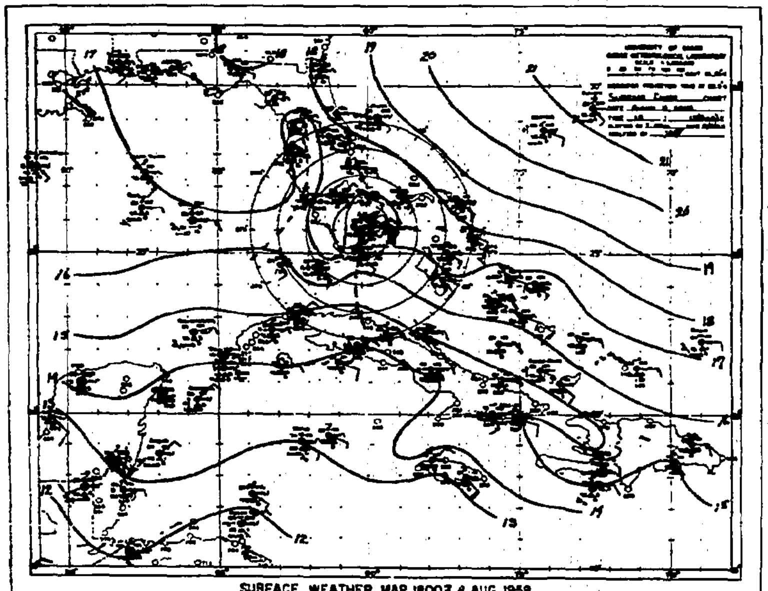


FIG. 13 (LEFT)—
RADAR COMPOSITE
1730-1735Z
26 AUGUST 1961

angles to the band. The echo area southeast of Lake Okeechobee and extending to the east coast seems too large to be entirely a sea-breeze front. The time section for Miami (Figure 6) indicates a trough near 11,000 ft at 1800Z on 26 August with the suggestion that it would have been as low as 3-5000 ft MSL 3 hrs earlier assuming steady state. Since other charts indicated that this was not a steady-state situation, the trough probably did reach the surface near Miami about 1500Z. A movement of 10 knots would put the surface position of the trough some 30 n. mi west of Miami at 1800Z. This trough evidently is associated with the mesoscale wave and the maximum-height band in question. The time section also indicates that the trough extended at least to 16-18,000 ft. Thus, the author concludes that sea-breeze effects may have been additive in certain portions of the band, but it is also associated with a wave that had history aloft.

It is reasonable to expect that with more data there would be more maximum- and minimum-height bands. Such was the situation of 8 August 1958, as presented in Figure 14. For this situation there were about twice as many echo-height data as compared to the situation in Figure 12. The spacing between maximum-height bands was about half of that in the previous figure or 50 n. mi. The maximum-height band along the coast east of Miami corresponded favorably with the wave axis there; however, there were no other waves analyzed within 80 n. mi of Miami for correspondence with the other maximum-height bands. Possibly, if hourly rather than 6-hourly data and continuity were used, more waves could have been analyzed. In certain instances, mesoscale waves or troughs approximately 50 n. mi apart can be analyzed from conventional synoptic data. An example of this is presented in Figure 15. An echo-height study of this situation, which was just prior



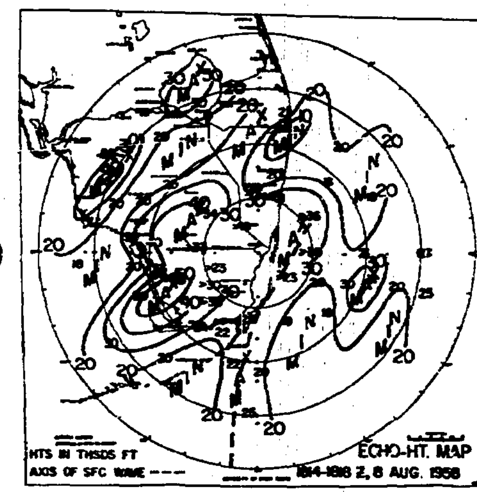


FIG. 14 - 1800Z
8 AUGUST 1958
SITUATION

Sfc. Map (Left)
Echo-Ht. Map(Right)

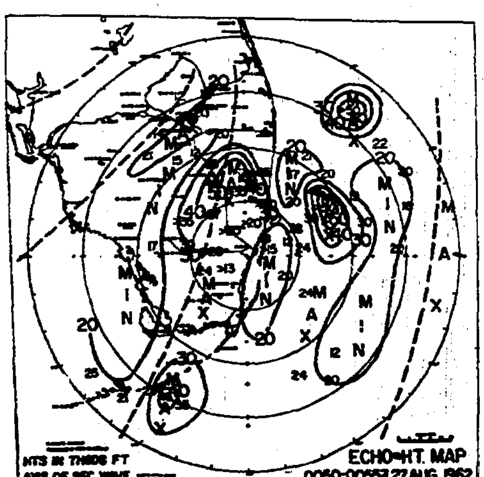
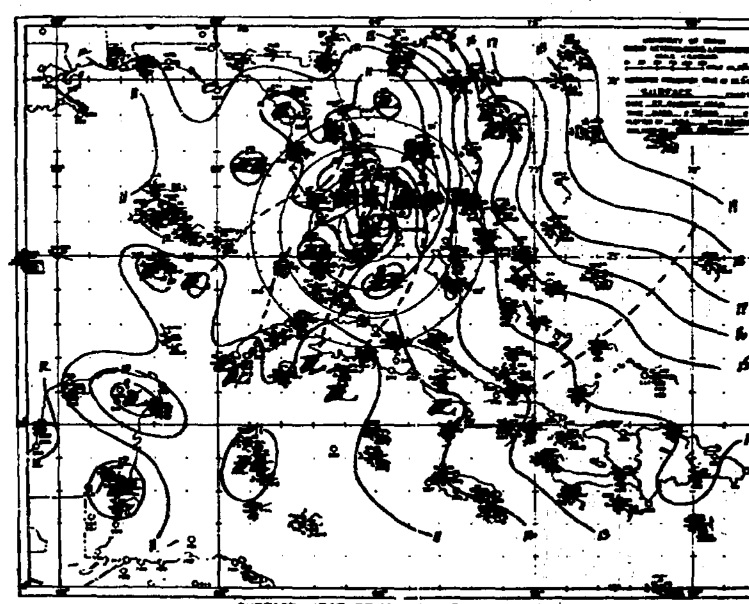


FIG. 15 - 0000Z
27 AUGUST 1962
SITUATION

Sfc. Map (Right)
Echo-Ht. Map (Left)



to the formation of hurricane "Alma" (1962), also indicated good correspondence between the maximum-height bands and the axes (see Figure 15). Although these mesoscale troughs were associated with a rather large vortex in a synoptic-scale wave in the easterlies, they do not strictly qualify as "mesoscale waves in the easterlies", because they are located along the southern side of the vortex with localized westerly flow aloft. Waves embedded in the localized westerly flow do not have the basic structure defined earlier. Therefore, the example is for illustrative purposes only. This suggests that after further verification of this study, maximum-height bands on echo-height charts may assist with the location of various sizes of mesoscale waves in the easterlies which could not be analyzed from conventional synoptic data.

In Figure 14, sea-breeze effects also may be additive. However, rather high echoes extending off the coast near Cape Sable suggest that some other disturbance was in the area. Note also in this situation that a maximum-height band exists along the coast just east of Miami, whereas in the previous example there was a minimum-height band in this area.

Conceivably, with increasingly large numbers of echoes, the maximum-height bands would become correspondingly closer together. By definition, the smallest mesoscale wave would be 2 mi in wavelength. This is roughly the scale of "cloud streets" as observed in Florida during the early afternoon in August.* Thus, there may be some remote connection between certain "cloud streets" which are perpendicular to the wind and mesoscale waves in the easterlies. On this scale the maximum-height bands would correspond to the

*Personal communication from Mr. Vernon Plank, Aerophysics Lab., Air Force G.R.D., Cambridge, Massachusetts.

cloud rows and the minimum-height bands would correspond to the regions between the rows which are nearly cloud free.

3.3 Concluding Remarks

The consistency of the results to essentially substantiate that a well known classical cloud pattern for synoptic-scale waves in the easterlies apparently is valid on the mesoscale as well was encouraging. More exhaustive studies should be attempted along these lines based on a much larger sample involving diurnal and hourly data, if possible. Radar may prove to be very helpful in locating mesoscale waves in the easterlies as well as tracking them.

4.0 PROGRAM FOR NEXT INTERVAL

Echo motions for the situation of 0000Z, 27 August 1962, which was just prior to the formation of hurricane "Alma", will be studied. Precipitation studies will be performed on this and other situations which have been investigated to date. Primary emphasis will be on patterns. Other parameters such as clouds will receive additional attention.

Since easterly waves usually invade Southern Florida fairly often during the summer, a particular effort will be made to collect radar data on certain ones especially for this project. Programs will be designed so that a variety of pertinent data are acquired near synoptic times.

5.0 PERSONNEL

Percentage of time worked by Project Personnel during the period 1 January - 30 April 1963 is listed below.

Personnel	Position	Percent
Homer W. Hiser	Project Supervisor	10
Harold P. Gerrish	Principle Investigator	100
David L. Adams	Part-time Student Asst.	50
Dale R. Hayden	Part-time Student Asst.	50
Rudy B. Lauterbach	Part-time Student Asst.	50

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3rd Interim Technical Report, 1 January 1963 - 30 April 1963, 30 pp. (Contract DA-36-039 SC-89111) DA Project 3A99-27-005. Unclassified Report.

Comparison of echo motions with winds aloft for a case study of 1800Z, 25 August 1961 is presented. Particular reference is made to the translational motion of precipitation echoes in the tropics, as determined by tracking selected small echoes and cells. These echo motions agree best with the 3-23,000-ft mean-layer wind, with both the 3-10,000-ft mean-layer wind and the 10,000-ft wind as next best.

Preliminary results of an echo-height study of certain mesoscale waves in the easterlies are also included. These results essentially suggest that a well known classical cloud pattern for synoptic-scale waves in the easterlies is valid on the mesoscale as well.

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